

## Urban Resilience to Floods in Coastal Cities

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1 | **Urban Resilience to Floods in Coastal Cities: Challenges and Opportunities for [Ho Chi Minh City and other](#)**  
2 **Emerging Cities in Southeast Asia**

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11  
12 **Abstract**

13 *Flooding is a hazard in many cities despite the presence of flood protection systems. However, recent losses and damages due to*  
14 *flooding in many coastal cities have indicated that the increasing volatility of natural disasters and flood events are now*  
15 *exceeding present day design considerations. By comparing and deriving common lessons from case studies in New Orleans,*  
16 *Manila and Bangkok, this paper focuses on the extent to which coastal cities are becoming more vulnerable to flooding and*  
17 *argues that broader urban resilience in the planning process now has an increasing role to play alongside traditional flood*  
18 *defences. Given the present speed of development in SE Asia, there are opportunities for these ideas to be readily and rapidly*  
19 *incorporated into development plans to reduce the severity of increasing flood events in the region.*

20  
21 **Keywords**

22 Urban resilience, flood vulnerability, spatial planning and management, coastal city  
23  
24

## Introduction

*"I urge local authorities to accelerate all efforts take cities safer to prevent the loss of lives and assets"* (Ban Ki-moon, 2009; cited in United Nations-Habitat, 2009).

Floods in urban areas continue to make headline news throughout the world with the increasing frequency and severity of events often attributed to climate change (Zevenbergen, 2008). In a review of significant events from 1980 to 2009, Doocy et al. (2013) attributed flooding to be the cause of 539,811 deaths, whilst affecting a further 2.8 billion people all over the world. Whilst extreme events can cause long-term devastation, even small floods can have a significant impact on urban activities. The standard response to mitigate against flooding is via flood defense systems. These can take on many forms - coastal dike, river embankment, dam and levee system, but they typically have design constraints (e.g. built to withstand a 100-year flood). There is clearly a need to balance probability with cost benefit, but in a changing climate, the likelihood of extreme events continues to increase and this has meant in recent years that flood protection systems have not always proved effective in dealing with the disastrous effects of large scale flooding. This is demonstrated by many recent examples of 'protected' cities worldwide which have subsequently suffered substantial losses to floods; in America (New Orleans 2005), Europe (Lancaster – United Kingdom 2015), China (Guangzhou-Guangdong, 2007), Australia (Brisbane 2011) as well as a number of cities in South East (SE) Asia (Manila – Philippines 2009, Bangkok - Thailand 2011 and Ho Chi Minh City – Vietnam 2015)

The flooding problem can be particularly acute in coastal cities. Of the 20 largest cities in the world, 13 are located on the coast (World Bank, hereafter called WB, 2010), with more than 20% of the world's population now living in the coastal zone (du Gommès et al. 1997; Brooks et al. 2006). -The low-elevation coastal zone (LECZ) normally refers to land that is less than 10 meters above sea level (Vafeidis et al., 2011, International Panel on Climate Change - IPCC 2014). Whilst tidal flooding and storm surges have always been a hazard in the LECZ, vulnerability increases in a changing climate due to sea-level rise (Neumann et al., 2015), which is now estimated to be 74cm by the end of 21st century (IPPC, 2014). Cities in the LECZ are often also located on estuaries or at the mouths of major rivers. -This means the threat of flooding in this zone can also be fluvial (or often a combination of both). An illustration of this is the location of Manila city, based on the western shore of Manila bay and through which the Pasig and San Juan River traverse.

As the world becomes increasingly urbanized, pressure to increase development in the LECZ is also increasing, resulting in larger (or new) settlements facing flooding hazards (McGranahan et al., 2007). Ultimately, rapid urbanisation is producing a concentration of people assets in areas prone to floods, particularly built-up areas along major bodies (Zevenbergen, 2008). Such rapid development further contributes to the problem because of weak planning regulations in the wetlands, forests, floodplains and mangroves adjacent to the urban areas (often located in the LECZ) which provide a natural defense to flooding (United Nations - UN, 2013). For example, in a study of 76 developing countries, Dasgupta et al. (2012) highlights the gradual loss of coastal wetland through human actions resulting from urban expansion. Driven by economic growth, urban enlargement results in a concentration of citizens and assets outside of former centers. Enlargement is not new and can be traced back to the 19<sup>th</sup> century, where the industrial revolution prompted the expansion of towns and cities (Hall and Jones, 2011). -This trend has continued to this day and now over 50% of the world's population is urbanized (UN, 2014). -However, this growth is becoming increasingly difficult to accommodate and many cities have now expanded their territory without thorough consideration of the risks to living environment. Angel et al. (2005) examined the processes of global urban expansion and concluded that population had not actually been distributed according to the plans approved in almost all of the 90 cities surveyed; while Gentlemen (2007) relied on the estimation of the UN stated that only 5% of new developments had been exactly implemented alongside to their existing plans.

In this paper, the term "coastal city" is used to define an urban area where settlement has occurred on the LECZ and is vulnerable to flooding (which may be both coastal and fluvial). -According to Population Division of the United Nations (1993, cited in Nicholls, 1995), there has been a remarkable increase in the number of coastal mega-cities, which have the potential to be impacted by sea-level rise, from 13 in 1990 to 20 in 2010. Indeed, this feeds into a general trend of global cities becoming more vulnerable to disasters due to spatial development related to sprawling sub-urbanization widespread to areas prone to environmental hazards (National Research Council of The National Academies of the United States, 2006), creating a spatial redistribution of the population into vulnerable areas (Chang et al., 2012). As such, due to the rapid development experienced over the last few decades in SE Asia, a large concentration of increasingly vulnerable coastal cities has emerged in this region. Here, countries are targeting the economic growth associated with urbanisation, but this now means that urban expansion has spread to areas that are increasingly at risk from flooding and this is compromising the adaptive capacity of the broader city to cope with natural risks which is essential for the long-term planning for urban development (UN, 2013) but frequently overlooked by local government. Since 2008, the average growth rate in this region has been at around 6%, compared with the world average of around 2.4% (UN, 2015; UN, 2016). Linked to this is the second highest projected urbanization rate in the world from 1990 – 2020 (UN 2012, cited in Economic and Social Commission for

Asia and Pacific, 2013). Shortly, the rapid development has entailed higher flood risk to coastal cities in SE countries.

Resilience is an emergent approach to help cities dealing with natural hazards including flooding. Based upon the early concept of resilience in ecology by Holling (1973), ~~Mileti (1999) defines community resilience as the capacity to withstand hazards with a minimum of potential losses and damage to productivity and quality of life without outside assistance.~~ In relation to flooding, Liao (2012) expands this to the terms of “urban resilience to floods” as the capability of a city, which can tolerate flooding and reorganize itself in order to minimize potential fatalities and injuries while socioeconomic identity is still maintained; and this requires a shift in process from resistance to resilience in practices with three key properties related to preserving individual safety and urban identity: “*localized flood-response capacity, timely adjustments after every flood, and redundancy in subsystem*” (ibid). In relevance to urban spaces, effective land-use planning and management is one of important objectives to reduce physical exposure and vulnerability for resilience improvement (Rockefeller Foundation, 2014; cited in Coaffee and Lee, 2016). Besides, Mileti (1999) defines community resilience as the capacity to withstand hazards with a minimum of potential losses and damage to productivity and quality of life without outside assistance. Research to improve resilience to flooding is now receiving considerable attention but there remain few studies that have focused on the relation between urban spatial development and flood resilience, a gap that this paper seeks to address.

## Methodology

The aim of this paper is to investigate significant flooding events in coastal cities around the world to determine what lessons can be learned for potential improvements in planning and managing urban spaces in order to enhance resilience. Given the large scale expansion of cities, this paper primarily uses a case study approach to document the impacts of key flood events in the SE Asia (e.g. Manila and Bangkok). However, for contrast, the high profile impacts of Hurricane Katrina and Hurricane Rita in New Orleans are also documented. Finally, the key conclusions drawn from the case studies are applied to Ho Chi Minh City, a city in SE Asia with an emerging flooding problem.

## Case studies

### *Katrina and Rita in New Orleans - USA 2005.*

The devastation caused by Hurricane Katrina in August 2005 is one of the biggest natural disasters in American history resulting in significant impacts in the Gulf Coast Area, including New Orleans city. -Whilst the magnitude of the event was the primary cause of most of the impacts, it was exacerbated by massive human failure during the event (Cigler, 2007). The scale of the storm surge striking flood defenses had not been well predicted, and the design of the flood protection was broadly inadequate for such an event (Pettersen et al., 2006). -Indeed, post-event the levee system actually helped retain the water within the city at depths of up to three meters. -Due to the poor prediction about intensity of this event, many citizens had remained in the city due to their confidence in its flood protection system. Unfortunately, once the scale of the disaster became apparent, the lack of available transportation not only prevented them from escaping, but also constrained the evacuees returning to the city after the flood (Cigler, 2007). Ultimately, the high flood magnitude originated from insufficiently considering the limitations of the region for urban spatial enlargement, with many areas of the city being developed about two meters below sea level on average (ibid). This development ensured that the city was totally reliant on flood defenses, the insufficient maintenance of which meant that the levee system was nearly one meter lower at the time of Katrina than its original construction (Pettersen et al., 2006). -Wetland development was also common, reducing the areas natural resilience to disaster, driven by the popularity of living at a waterside location (Cigler, 2007).

### *Ketsana (Ondoy) in Manila - Philippines 2009.*

This flood was mostly caused by heavy rains accompanying a tropical storm in Metro Manila where several parts were inundated in September 2009. Manila city, which is located in this region, experienced fluvial flooding from the Pasig and San Juan Rivers despite the significant investment in a flood management system consisting of a dense network of floodways and reservoirs (Sato and Nakasu, 2011). The system had been exceeded by actual discharge in reality (ibid). -Whilst inadequate flood management was clearly a contributing factor, illegal settlement on low-lying flood plains had decreased the natural capacity of the system in relevance to human interactions to watercourses. Floodways in these areas had been also blocked with rubbish from inhabitants (ibid). The city had significantly expanded its urban area over recent decades, but development had been generally inappropriately planned and urban river channels were mostly inadequate (Muto et al., online). -Despite the magnitude of this flood, the degree of the impacts was reduced mostly due to an established shelter network, and the experience of citizens and the government collected during previous events.

### *“Thai flood” in Bangkok – Thailand, 2011.*

Although water levels in 2011 were lower than other historic events in 1942, 1983 and 1995 (WB, 2012), the length of the 2011 flood made it a hugely significant event in Bangkok. Starting in June 2011 and lasting for five months, the flooding was a consequence of a series of prolonged heavy monsoon rain and storms, which produced consistently high precipitation leading to the downstream from the North to the lower plains of the Chao Phraya River Basin, where it frequently met with high tides. The peak impact was realised in Bangkok city in November 2011 when nearly the whole city was immersed. -The flooding scale was exacerbated by inadequate weather

forecasts, which affected storage, and discharge options, meanwhile the intensity of rainfall meant the 10 major flooding protection schemes were breached, leading to widespread inundation over the city from the Thailand Gulf (ibid). Although the evacuation of inhabitants helped reduce the impact, the long duration of the event caused a chaotic situation across a large part of the country.

## Discussion

The three case studies chosen in this paper are clearly all very different, yet there are also many similarities and opportunities to take forward and learn from these events (Table 1). Whilst the cause of flooding is ultimately natural, the geographical location of each city in the LECZ (and associated inadequate planning decisions) along with human failures have significantly increased the impacts of the events. The common problems of urban planning and management related to resilience are:

- Flood protection based on engineering structures is not a sustainable solution to all floods, and many established flooding defenses are obsolescent for extreme events in light of unpredicted changes of natural conditions such as water level, precipitation and land subsidence.
- Uncontrolled settlement along water bodies that has not only resulted in more residences being vulnerable to floods but has compromised natural flooding protection systems;
- Resilient infrastructure, with the crucial role of transportation, is often lacking but is essential to ensure continuity of urban functions or ultimately aid evacuation (e.g. transport and shelter networks)
- The importance of precise information (e.g. weather forecasts) to ensure both citizens and the government can make timely decisions is often not available.

### *Resilience to floods: integration into spatial planning and management*

As the case studies in this paper highlight, coastal cities are increasingly reliant on the effectiveness of flood protection systems. Whilst these are designed to cope with extreme events (e.g. the 100 year flood), it is becoming clear that in a changing climate this may not be adequate and traditional principles may no longer be appropriate (Rogers et al., 2012). Estimates of current flood protection are normally based on knowledge accumulated from the historic weather record but climatic features are now more volatile (Zevenbergen et al., 2008). It appears that, the limited effectiveness of flood defenses to the volatility of a changing climate is becoming a serious threat. Furthermore, the presence of such protection system can lead to complacency and actually encourage further vulnerable developments by attracting population and assets on vulnerable areas (Hallegate, 2013). It is clearly impractical to continue to build ever-higher flood defenses, and there is a need to look at alternative means to improve urban resilience to flooding. As such, sufficient management of urbanization processes is crucial to ensure ongoing resilience. The case studies used in this paper highlight that inappropriate (and sometimes illegal) urban expansion onto wetlands and floodplains is frequently common practice, reducing natural resilience and exposing more citizens to flood risk.

Whilst the enlargement of cities is inevitable, the consideration of natural hazards such as flooding, especially in a changing climate, cannot be ignored; this has emerged the need of integrated resilience. Cities need effective planning for urban spaces and new developments should attempt to avoid the 'quick and easy wins' associated with building on vulnerable areas such as lowland adjacent to rivers and coasts (even if these areas command the highest real estate values through their desirability). As an alternative, compact development on in naturally resilient central areas, advanced lands (eg. high elevation) could be targeted to leave more open spaces between which transportation can take account as interlinks. There is much available evidence to support the benefits of spatial compactness to improve transportation efficiency and to reduce emissions in cities (McLaren, 1992; Bozeat, 1992; Rickaby, 1992; Matsumoto, 2012). Indeed, through recent testing of the compact city index in 41 Japanese cities, Lee et al. (2015) believed that the transportation network can contribute to improvement of urban compactness for sustainable development. However, the costs of compact development can be high whereas the development of surrounding areas, such as wetlands, are normally low-cost, and offer affordable housing for migrants on low-incomes. In addition, land directly adjacent to water-bodies is attractive to those on high incomes and offer significant profit potential for developers. These two factors result in a high-demand for such locations, the development of which needs to be strictly managed by local government. However, the higher costs associated with compact development can to some extent be offset by the need to invest less in flood protection systems. The savings of which are further realized in the event of severe flood which breaches defenses (i.e. the significant costs and losses experienced in New Orleans & Manila). For physical infrastructure, the lack of efficient role of available transportation for resilience has also been emphasized. The importance of emergency routes in case of extreme floods is clear and the number of fatalities in New Orleans would have been significantly reduced if key elevated or 'hardened' roads were available. Such roads would be linked to other elements of critical infrastructure in the city (i.e. medical facilities) and higher topographical land in the city should be reserved for such purposes. These are in line with recent thinking from the UN (2013) stating that "A new wave of urbanization is unfolding in hazard-exposed countries and with it, new opportunities for resilient investment emerge". Furthermore, Besides, the importance of the scientific community in developing accurate forecasts and how this information is conveyed to communities can very much underpin their resilient capability. The case studies chosen

demonstrate the importance of effective communication between community and government when dealing with disaster. In vulnerable locations, early warning system accompanied with clear action plans for certain scenarios are essential. This provides the tools to enable individual adaptation based on the notion that community resilience can be consolidated by an ability of learning experiences and solving problems (Berkes, 2007). Fundamentally, early preparation is always more effective (Godschalk, 2005), but this requires a change towards transparency of information about flooding risks to reduce over-confidence in hard engineered solutions. Overall, people need sufficient information to make an informed choice with respect to risk, adaptation and resilient capacity in their living environment.

In summary, planning and governance is at the centre of this discussion. Coastal cities need to be consolidated and resilient spaces created for development rather than unique investments using conventional flood protection systems. It is accepted that this creates more pressures on authorities by ensuring this process is under control according to an approved master plan containing detailed strategies for flood risk management in reference to land-use. Ultimately, the government system has to control urban changes across different sectors such as water resources, land use and construction, housing and human settlement, transportation and mobility, economy and trading as well as policy and governance perspectives. These are in line with recent thinking from the UN (2013) stating that “A new wave of urbanization is unfolding in hazard-exposed countries and with it, new opportunities for resilient investment emerge”.

#### ***Implications for emerging cities in SE Asia, especially in HCMC***

Aforementioned, the lessons learnt from the flooding incidents should become the opportunities for coastal cities, especially for ~~SE Asian~~ emerging cities, which are defined as on-going rapidly developing urban agglomerations in emerging economies ~~in SE Asia~~ (UN, 2016, table 1; Pena et al., 2014). They can enhance resilience due to the significant ~~economic~~ growth driving an integration of resilient objectives into urban planning, ~~essentially many of them demonstrate distinct growth which could be potentially constrained by climate change.~~ Low-income countries, ~~such as those in SE Asia,~~ are considered more vulnerable to natural disasters than developed countries because of the larger proportion of their resources threatened (WB, 2010). ~~In particular~~ Especially in Southeast Asia, the World Bank (2010) highlights three “hot-spots” ~~in the region~~ having a predicted increase in population but with assets at considerable risk to flooding: Manila, Bangkok and Ho Chi Minh City (HCMC). These cities alone are expected to expand into increasing flood-prone areas from 30% to 70% with the cost of damages ranging from 2% to 6% of regional Gross Domestic Product (ibid).

~~Moving to the previously undiscussed case of HCMC~~ In this context, this city HCMC has also seen increasing vulnerability to floods due to the effects of rapid urbanization and climate change in recent years. For 40 years, its population and territory have increased four-fold (General Statistic Office of Vietnam, 2015) with new suburbs rapidly appearing on the former wetlands to the South and Southeast of the city, for example, the developments of Phu My Hung (409 ha, in district 7) and Thu Thiem (657 ha, in district 2). ~~Alongside this~~ For the climatic changes, maximum water levels have increased about 35cm for 34 years (SRHC, 1981 – 2015), whilst some extreme rainfalls were recorded in 2016 (eg. the 40 years return precipitation of 204 mm during two hours in September 26<sup>th</sup>, 2016 (SRHC, 2016). ~~Obviously, HCMC has realised the nature and potential problems and can potentially learn lessons from the three case studies considered here. HCMC~~ In consequences, this city now has more than 50% of urban land affected by regular floods (Asia Development Bank - ADB, 2010) although it has only rarely experienced floods prior to the 1960s, (Hong, 2010);, but it now has more than 50% of urban land affected by regular floods (Asia Development Bank - ADB, 2010). ~~Critically, this city has realised the nature and potential problems and can potentially learn lessons from the three case studies considered here, but~~ Critically, the local government is still following the resistant strategies, including investment in flood defenses. There have been debates on the effectiveness of ~~existing~~ harden-engineering projects which have now cost about 1.2 billion USD, as well as doubts on the feasibility of a new proposals for continued construction estimated at a further 4.4 billion USD (Nguyen, 2015). Instead of such investments, HCMC has much to learn from Manila and Bangkok as the challenges actually originate from uncertainty of climatic change, with rising sea levels and higher rainfall intensity and frequency becoming the norm and overwhelming existing flood defenses. As the city expands into former marshlands to the south and east of the city, ~~this situation will deteriorate further and hence,~~ the arguments for compact development in the higher altitude ‘old town’ along with hardened transport routes appears a sensible forward option. For increasing accommodation as the urban continued growth, higher floors in residences could be allowed for further developments (eg. For example, the apartment projects in district 2) can be seen alongside as long as they ensure spatial compactness strategies (more effective architectural designs: lower height, maximised spaces etc.), as long as they are located on higher land, and sufficient distance from water bodies. On the positive side, ~~Alongside to this,~~ the residents can get benefits from more affordable prices (60% reduction in comparison to private houses), ~~but the associated open spaces, eg. local parks, still needed to be secured.~~

Such pressures are not limited to HCMC and they are evident across the region (Hallegatte et al. 2013; World Wildlife Fund, 2009), with many coastal cities, facing an increasing threat from floods unless resilience becomes better integrated into development master plans which clarify which areas can be made resistant or resilient to flooding. Flood risk assessments need to be shared with communities so that it is not only used for management by



authorities but adds transparency for residents who should acknowledge what risk level they can accept for living environment in adaptation. This therefore can improve community resilience, and on the other hand reduce pressure of protection by hard-structures resistant to floods.

## Conclusion

As demonstrated by the case studies compared, coastal cities across the world are becoming increasingly vulnerable to flooding ~~and climate changes~~. This paper emphasizes that inappropriate spatial planning for urban development can be a primary cause of the increased vulnerability as the results of the rapid growth of new residences in flood prone areas whilst decreasing urban resilience to ~~flood hazards related to~~ extreme weather. ~~The trend of b~~Built-up areas encroaching water bodies for aesthetic purposes has commonly portrayed local governments investing intensive flood defences which are considered expensive but unsustainable solutions to increasingly volatile climate in recent years. This trend is more emerged in SE countries because of their willing of distinct growth.

Emerging-coastal cities in SE Asia would face the challenges similar to the lessons mentioned, as the conventional strategies are the delivery of flooding defences; adversely, undermine urban resilience. Such hard-protection system is believed to reduce community resilience while these cities are actually "adaptive" to adversities. Instead, there is a growing need to An improve-improvement of flood resilience is feasible in practice. Firstly, it is essential to reduce high density of resident put a constrain on developments on floodplain which should be left for open spaces; subsequently the sufficiency of land use planning and management is simultaneously essential, and. To accommodate further growth in vision, compact spaces should be comprehensively performed from building scale upwards, particularly in former central zones or new advanced areas (eg. higher lands with sustainable hydraulic network). Secondly, resilient infrastructure involving the vital role of transportation constitutes a success of resilience to floods, such as evacuation routes in case of extreme floods. Finally, these cities should improve the ability of integrated forecasting extreme weather related to severe floods. These recommendations ~~can be~~ believed to be possibly ~~applied to emerging cities in SE countries as they are believed to have opportunity for potential adjustments to the plans for urban spatial development driven by their prospective economic growth. This also informs an opportunity for HCMC to revise the current strategies of flooding management.~~

For HCMC, it is essential to evaluate the efficiency of the existing master plan for flood management in relevance to further investments in defence system such as embankment, sluices. To a prolonged strategy, "a timely adjustment" to spatial plans for urban development, and changes in management policies are necessary particularly in new development areas, while hard-constructions of flood defense should be thoroughly evaluated. Open spaces are essential to incorporate in the master plans, while the contributions of resilient buildings to floods should be required when approving of construction. By doing these, the city can save further cost of flood defence structures, and minimize the unexpected effects of water discharge on the natural system; while a part of such budget can be delivered to community resilience such as comprehensive plans for emergency evacuation or improvement of water storage by households.

Overall, globalisation and economic growth are stimulating ~~ever greater levels of investment and this has an ever-greater level of investment and this has~~ become a driving factor for new projects and urban expansion in SE Asian cities. These cities, which used to be adaptive to environmental challenges since their early establishment, can improve their resilient capacity if they can learn from the lessons mentioned, and utilize the driving factors of economic development to adjust their strategic plans from resistance to resilience, accompanying with more innovative management policies. The rapid growth is presently causing problems, but it also affords fantastic opportunities for the integration of urban resilience into development masterplans, ensuring not only flood resilience but economic resilience. Resilient theories can be developed to enhance the planning, designing and management of the cities in the future; and ~~this also~~ this encourages further research on a combination between resilience and compactness in practices.

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